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## **Concrete Masonry Walls Offer Economical Fire-Resistant Design in Multi-Residential Structures**

*The following is an article written for publication in magazines and to the architectural, engineering and legislative communities about the mission of balanced design and the cost of non-combustible concrete construction.*

Providing life and property protection is a significant part of the design and building process as well as the focus of the International Building Codes now in place throughout the United States. The Codes were developed using a minimum requirement for the building of all residential and commercial structures. There is a concern that the minimum requirements for fire safety especially for multi-residential structures – townhouses, dormitories, assisted living facilities, small hotels, etc... - may not provide enough protection for elderly, college students, disabled and families dwelling in these units.

A movement is underway to increase the level of fire protection in codes by using the balanced design approach to construction. Balanced design is an approach that considers three fire safety options. The first component is “containment” with structural walls, floors and ceilings of masonry and concrete that provide 2 to 4 hours of protection. The second is “detection” with smoke detectors to alert residents to evacuate. And the final component is “suppression” using sprinklers to control the fire until the emergency responders arrive on the scene. Balanced design may suggest that one or two of these components is adequate for a few occupancies. However, for housing the elderly, disabled, students, and families, the building code may be lax if the superior fire protection offered by combining all three components of balanced design were not mandatory for multi-family construction.

Each of the three components is very important, but work under differently. Balanced design considers both active and passive methods of fire protection. Detection and suppression systems are active systems. While detection systems are electrical, hard-wired systems have battery back-up in the event of a power failure. Most suppression systems (sprinklers) require a water source which may or may not be available in the event of a fire.

Containment with compartmentation is a passive system that does not require anything to activate. Compartmentation with concrete products that will not burn and will maintain their structural integrity is a vital part of the equation. If a fire were to start within a given room or compartment of a building, the non-combustible walls, floor and ceiling would contain the fire allowing time for fire fighters to arrive and extinguish the fire or for a sprinkler head to deploy and control or even extinguish the flames.

Currently, many codes provide for detection and suppression, but they do not require non-combustible compartmentation between dwelling units. A significant argument made for not using compartmentation has been the misperception that use of concrete and masonry would increase the cost of construction so significantly as to make it cost prohibitive. There have been many case studies on initial and life cycle costs showing the advantages of concrete and masonry construction for multi-family dwellings, yet recommendations to improve fire protection in multi-family dwellings have been denied based on unfounded claims of excessively high costs.

In order to clarify and accurately document the actual cost of constructing with concrete products versus wood and steel framing for interior separation walls, floors, and ceilings; a study was commissioned by several groups who have as their mission to improve life safety and property protection with non-combustible construction. The New York/New England, Pennsylvania, and Mid-Atlantic Fire Safety Construction Advisory Councils (NY/NEFSCAC, PAFSCAC, and MAFSCAC, respectively) came together

to commission a study to show initial cost of construction. Previous work has been done addressing life cycle costs which emphasized the long term benefits of concrete based construction versus wood framing and light gauge steel, but this study specifically addresses initial cost.

With this new study, the industry now has documentation that the cost difference is much lower than perceived by many outside the concrete and masonry industry. In many cases, the cost differential was 5% or less and, indeed, in one instance it was actually less for non-combustible concrete construction.

The objective of this study was to develop a model to accurately evaluate the relative construction cost of multi-family buildings built using a variety of construction materials. The multi-family occupancies modeled were representative of traditional apartment type buildings, condominium style buildings, student housing, elderly housing, and others.

### *Design*

The design firm hired for the project was Haas Architects Engineers, a multi-disciplinary architectural and engineering firm located in State College, Pennsylvania. Haas Architects Engineers has a thirty year history of client centered service including commercial, single and multi-family residential, retail, and sports based projects. The principal investigator from Haas Architects Engineers, Walter Schneider, III, Ph.D., P.E., is also a volunteer fire fighter.

Two types of four-story multi-family dwellings using various construction types were evaluated for three locations in the Northeast United States:

- ✓ Framingham, Massachusetts
- ✓ Harrisburg, Pennsylvania
- ✓ Towson, Maryland

Each building model encompassed approximately 25,000 gross square feet of building area per floor. The first model is a building comprised exclusively of single bedroom dwelling units, intended to be representative of student housing, some types of housing for the elderly, hotels, and motels. The second model is configured using a mix of one and two bedroom dwelling units, intended to be more representative of apartments and condominiums, as well as some types of housing for the elderly. Each building model included the complete fit out with the exception of movable appliances and furniture. For all cases, the exterior is brick and the building is fully sprinklered.

The building construction types, designed using the provisions of the 2003 International Building Code, included:

- ✓ Conventional wood framing with wood floor system (Type 5B Construction)
- ✓ Conventional wood framing with wood floor system (Type 5A Construction)
- ✓ Light gauge steel framing with cast-in-place concrete floor system on metal form deck
- ✓ Load bearing concrete masonry with precast concrete floor system
- ✓ Load-bearing concrete masonry with cast-in-place concrete floor system
- ✓ Precast concrete walls with precast concrete floor system
- ✓ Insulated concrete form walls with precast concrete floor system
- ✓ Insulated concrete form walls with cast-in-place concrete floor system
- ✓ Insulated concrete form exterior walls with interior bearing walls constructed of concrete masonry units and precast concrete floor system

### *Code Compliance*

Tim E. Knisely, a senior fire and commercial housing inspector for the Centre Region Code Administration, in State College, Pennsylvania, evaluated the designs for code compliance. Mr. Knisely currently holds a certification as a registered Building Code Official in the Commonwealth of Pennsylvania and holds more than eight certifications from the International Code Council. In addition, Mr. Knisely has been involved in the fire service for more than 20 years.

Once design was completed on each of the buildings, Mr. Knisely performed a detailed code review following the requirements of the International Building Code 2003 edition. This review was conducted following the plan review forms provided by the International Code Council. This review was in addition to the review performed internally by the professionals at Haas Architects Engineers.

The report precluded a number of items that are common to all of the buildings. These are items dealing with site issues, soils information, etc. All of these items are common to each of the buildings and would add identical cost to each project. This was verified with the cost estimation personnel at Poole Anderson Construction.

**Cost Estimation**

Poole Anderson Construction is one of the largest building contractors in Central Pennsylvania with a 75 year history and an annual construction volume exceeding 60,000,000 dollars.

To allow for a fair and uniform comparison of the construction costs between trades, the cost study used accepted prevailing wage rates published for each of the locations. These labor rates are typical for a publicly funded project and allow for a fair labor comparison by eliminating potential cost undercutting by any of the trades.

**Results**

There are many reasons for selecting construction type, including initial cost, speed of construction, life cycle cost, insurance costs, environmental sustainability, energy performance, durability, noise control, structural integrity, natural and man-made disaster resistance, degree of maintenance, and fire protection. The final report contains the actual costs for the various building construction types. The study provides the relative cost as a comparison to wood frame as a baseline of 100%, indicating increases or decreases relative to the baseline. Cost percentages shown below are examples of those provided by the complete study.

Most Economical Concrete and Masonry Systems Compared to Wood Frame

Location	Relative Cost of Concrete and Masonry	
	One Bedroom Scheme	Mixed Bedroom Scheme
Framingham, MA	5 % more	1 % more
Harrisburg, PA	5 % more	2 % more
Towson, MD	3 % more	3 % less

**Conclusions**

Based on the construction cost estimates prepared by Poole Anderson Construction, the increased cost of using non-combustible concrete construction materials versus traditional wood framing or light gauge steel is minimal (3 – 5%). Comparatively speaking this amount is less than the contingency budget typically recommended to the owner for unanticipated expenditures during the project.

The minimal increase in construction cost will also pay for itself over the life of the structure. Materials like concrete masonry, precast concrete, and cast-in-place concrete have many other advantages beyond their inherent fire performance including resistance to mold growth, resistance to damage from vandalism, and minimal damage caused by water and fire in the event of a fire in the building. In many cases, with this type of construction the damage outside of the fire compartment is minimal. This provides for reduced cleanup costs and quicker reoccupation of the structure.

**Availability of Reports**

Summaries and complete versions of the detailed report are available from the PCMA office.

*Further Studies*

Responding to the importance of this information for increasing life safety and property protection by the use of non-combustible concrete construction other industry groups are planning studies for their areas. Future studies are currently planned for:

Indianapolis, Indiana  
Dayton, Ohio  
Albany, New York  
Rockford, Illinois  
Richmond, Virginia

Chicago, Illinois  
Phoenix, Arizona  
Washington, DC  
Merrville, Indiana

Philadelphia, Pennsylvania  
Pittsburgh, Pennsylvania  
Frederick, Maryland  
Mellville, New York